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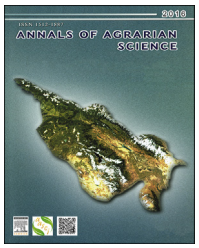

The ecological problems of rivers of Georgia (the Caspian Sea basin)

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ABSTRACT

The increasing demands of fresh water in the world threaten the biodiversity and the supply of water for food production and other vital human needs. Providing adequate quantities of pure, fresh water for humans and their diverse activities is the major problem worldwide. In spite of the fact that Georgia is considered rather rich of fresh water resources our research showed that the major rivers of The Caspian Sea basin are polluted with different contaminants like, nitrates, ammonium nitrogen. Heavy metals, oil products, pesticides and other toxic chemicals. From researched rivers the most polluted are Mashavera and Kazretula (Bolnisi Municipality). They are mainly contaminated with toxic releases of joint-stock company, Madneuli's activities. The rivers are also polluted from other plants, agricultural activities and farms. To protect the public and the environment from toxic releases the government should prevent pollution by requiring industries to reduce their use of toxic chemicals and restore and strengthen protection for all water objects. Concerted actions are needed to safely manage the use of toxic chemicals and develop monitoring and regulatory guidelines. The principles and practices of sustainable development will help to contain or eliminate risks resulting from the chemical pollution.

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Introduction

One of the global problems today is the acute shortage of fresh water. The increasing demands placed on the global water resources threaten biodiversity and the supply of water for food production and other vital human needs. Water shortages already exist in many regions of the world, with more than one billion people without adequate drinking water [1]. In addition, 90% of the infectious diseases in developing countries are transmitted from polluted water. Nearly half of the World's population lacks adequate sanitation. This problem is acute in many developing countries, which discharge an estimated 95% of their untreated urban sewage directly into surface waters. Downstream, the untreated water is used for drinking, bathing and washing, resulting in serious human infections and illnesses [2,3].

Providing adequate quantities of pure, fresh water for humans and their diverse activities appears to be a major problem worldwide. New water supplies in future are likely to result from conservation, recycling and improved water-use efficiency rather than from large development projects [4,5].

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Results and analysis

Among various natural resources of Georgia water resources are one of the major national riches. Georgia was one of the first among former Soviet republics by the total amount of annually formed fresh water (810 mm). Presently, Georgia is the 87th in the world by the amount of renewable fresh water resources [6]. Georgia's total fresh water resources today are 100 km^3 and they are accumulated in rivers, lakes, glaciers, ponds, water reservoirs and ground waters. Among water objects the rivers are the most polluted.

Altogether there are 26060 rivers in Georgia with total length of about 60ths km. The rivers belong to two main basins which are divided by Likhi mountain ridge. 65% of them (approximately 18109) belong to the Black Sea basin and 30.5% (7951 rivers) to the Caspian Sea basin. Among these rivers hydrologically are studied 555 from the Black Sea basin and 528 from the Caspian Sea basin.

The hydrographical network of Georgia (99.4%) mainly consist of little (<25 km) and very little (<10 km) rivers. The average water flow that is formed on Georgia's territory is 56.5 km^3. Besides, from the neighbor in countries inflow 9.3 km^3 of water, among it: by means of Mtkvari river- 0.915 km^3, Fotskhovi river – 0.252 km^3, Debeda – 0.883 km^3 and Chorokhi – 7.25 km^3, altogether – 65.8 km^3. From this amount 49.7 km^3 of water flows into the Black Sea and 16.1 km^3 into the Caspian Sea through the territories of neighboring countries (Azerbaijan and Russia) [7].

The characteristics of big and middle size rivers, as well as, of some 50 km of length and more are presented in Table 1. Georgia's major river Mtkvari springs in Turkey and only it's middle part (351 km) flows on Georgia's territory. Almost all rivers of east Georgia make the common system of Mtkvari basin and flow into the Caspian Sea through Azerbaijan's territory.

The rivers of the country are characterized by strong zones of highland water flow elements. The zone of the west part of the Caucasus Ridge and the slopes of the Ajara mountains facing the Black Sea are characterized by full flowing. The average annual flow here is 3500 mm, while on Iori river's plateau in Kvemo Kartly there are dry ravines where water flows only after thawing of snow or pouring rains [8].

Table 1 – The characteristics of the big and middle size rivers of Georgia (the Caspian Sea basin).

Rivers	Length of river, km	Space of water collecting basin, km
Alazani	366/362[a]	11800
Mtkvari	1515/351[a]	188000
Iori	320	4650
Ktsia-Khrami	205/201[a]	8340
Algeti	118	763
DidiLiakhvi	98	2440
Ksani	84	885
Faravani	74	2350
Aragvi	66	2740
Mashavera	66	1300
PataraLiakhvi	63	513
Tethami	51	404

[a] The total length of the river/the length on Georgia's territory.

As already have been noted in many countries of the world fresh water deficit is observed now. The main reasons of it are: pollution of fresh water objects with insufficiently purified industrial discharges, decrease of natural water collecting areas, deforestation, inadequate agricultural production methods, etc [9,10].

One of the reasons of constant degradation of water ecological systems is inadequacy between the existed structures of production and consumption on the one hand, and requirements for use of water resources on the other hand. Such situation is observed in many countries of the world including developed ones.

For sustainable development of economy and rational utilization of water resources it's very important the ecological condition of water systems. Melioration, building of new reservoirs, urbanization and other type of technogenic and anthropogenic influence on nature provoke irreversible changes on formation of water flows, surface and ground waters' quantitative and qualitative indices on big territories. So, pollution of water objects is a great problem nowadays and requires appropriate solution [11].

In the process of natural waters pollution it is especially important their contamination with oil products, phenols heavy metals, complex organics (pesticides, detergents) and biogenic substances (phosphates, nitrates) [12].

Surface waters of the urban and industrial territories are characterized by composition of suspended substances like, oil products, toxic residues, etc. These products not only contaminate surface waters, but are accumulated on the bottoms of water reservoirs and promote to the secondary pollution. It is especially noticeable in small reservoirs and water flows.

On the ecological condition of water reservoirs adversely affect agricultural activities, especially the use of mineral fertilizers and pesticides. These long-lasting toxics are very strong to the external factors and preserve their toxic nature for long period. Pesticides and other chemical contaminants that enter water objects through agricultural runoff, storm water drains and industrial discharges may persist in the environment for long periods and be transported by water or air over long distances. The danger of water pollution from mineral fertilizers and pesticides is growing because the refinement of field water flows is practically impossible.

Industrial agribusiness is also a major contributor to nitrate pollution of our water objects. It comes from poultry and processing plants. In addition, fertilizers and other agricultural runoff also account for a large volume of nitrate pollution.

The toxic remains of fertilizers and pesticides are especially dangerous for water reservoirs because they promote to the intensification of eutrophication process (excessive nutrient levels in water), that increases the growth of algae and plants in waters, leading to an increase in cyanobacteria (blue-green algae). The toxics released during their decay are harmful to humans. Besides, it adversely influences on communal and technical water provision and fish farming. The most part of the water reservoirs must be examined and appropriate measures taken until eutrophication process not become irreversible.

Another serious ecological problem is the utilization, harmlessness, and safety storage of industrial and communal waste which harmfully influence on environment and people's health. The great part of waste contain easily soluble toxic compound that under influence of atmospheric precipitations easily get into ground waters and pollute them. The toxic elements getting into rivers and seas may cause the massive poisoning of ichthyofauna and through food-chains get into other organisms too.

In industrial pollution of rivers of Georgia significant role take heavy metals. The most toxic from them are: cadmium, copper, lead, zinc, manganese, mercury, etc. They get into water objects with unpurified industrial discharges. For many years into river Mtkvari flowed waste industrial waters that contained about 70 different substances, toxicants among them. The discharges from metallurgical and chemical plants into the river contained about 10ths mg/l of suspended substances, among them: 30 mg/l of ammonia, 2 mg/l of phenols, o.3 mg/l of pyridines, 0.1 mg/l of cyanides. Such composition of waters 100 times exceeds the limited permissible concentrations (L.P.C.).

The chemical composition of Mtkvari belong to the calcium-hydrocarbon class. Mineralization is growing along downstream, for example: at village Khertvisi it is within 91–281 mg/l, in lower part of Rustavi town it is 323–733 mg/l [13].

During last periods significant pollution of Mtkvari took place, for example, in 2006 by, "Tbilsresi" (Tbilisi regional power plant), 270573ths m^3 of industrial and communal discharges was flowed into the river without purification that contained 208t.organic substances, 3t.oil products and 5t.suspended particles. By, "Mtkvari-energetica" ltd. – 309 ths m^3 of industrial and communal toxic releases was flowed into Mtkvari without purification that contained 0.8t of organic substances, 0.04t of oil products and 15t of suspended particles. By, "Tbilaviamsheni" enterprise 534ths m^3 industrial discharges was flowed into Mtkvari with out purification that contained 1t of organic substances and 6.4t of suspended particles. The annual changes of ammonium ion in Mtkvari by years is presented in Fig. 1.

From ecologically critical objects should be mentioned joint-stock company "Madneuli", in village Kazreti (Bolnisi region). The enterprise produces copper concentrate. According to the project the closed water cycle production was provided, but by violating the technological process, acid open pit waters are constantly leaking and polluting rivers Mashavera and Kazretula. Accidental discharges of polluted waters are also dangerous. Leaking toxic waters often contain ph-2.5–3.5, accordingly copper is 25–56 mg/l that exceeds the L.P.C.

The major technological pressure takes place on hydro network and irrigation system. Kazretula is flowing under the tails of mines and is saturated with copper ore elements. The total contain of copper, zinc, cadmium and other sulfates in Kazretula much exceed L.P.C. Because of very low ph of water these elements are mainly in soluble form and are migrating. The same situation is observed in Mashavera. Near the "Madneuli" group of enterprises Kazretula contain 8.125 mg/l of copper, while L.P.C. is 1 mg/land at the place of flowing into Mashavera it is 1.212 mg/l. The total concentration of zinc and cadmium in both rivers is high too.

Well developed irrigation system of Bolnisi region starts from Mashavera below the place of flowing into Kazretula. So, the polluted hydro-net provoke the contamination of soils too. Mashavera's chemical composition is calcium-hydrocarbon: mineralization changes within 195–450 mg/l; oxygen solution in water –563 mg/l; organic substances 11–25 mg/l. The concentration of contaminants are: ammonium nitrogen – 1.66 mg/l; nitrite nitrogen – 0.122 mg/l; copper – 0.071 mg/l; zinc – 0.900 mg/l; phenols – 0.008 mg/l and oil products – 0.120 mg/l [14].

Khrami river is connected with Mtkvari from right side. There are 2264 creeks with total length of 6717 km, between them are Mashavera and Debeda that mainly flow on Armenia's territory. The formation of Khrami water flow takes place in Tsalka, Tetritskaro and Dmanisi regions and it is about 80% of its total flow.

In Khrami basin the most polluted is Mashavera and the major contributor is the "Madneuli" ore mining and processing enterprise. The polluted discharges from, "Madneuli" into Mashavera contain chemical toxicants (arsenic, phenols), oil products, nitrogen, copper and zinc components that 200 times and more exceed the L.P.C.

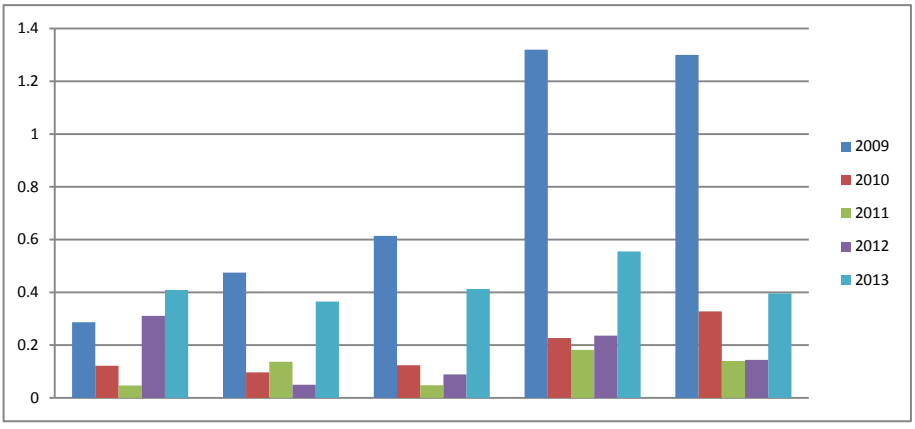

Fig. 1 – The annual changes of ammonium ions in Mtkvari river by years mg/l (2009–2013). Source: The National Environment Agency, 2014 [14].

Debeda river is polluted on Armenia's territory by Akhtala mining and smelting enterprise The polluted discharges contain ammonium and nitrite nitrogen (35 and 13 L.P.C.), copper and zinc (140 L.P.C.), phenols (14 L.P.C.) and oil products (10 L.P.C.).

Algeti river is very polluted with ammonium compounds (16–40 L.P.C.), sulfates (125 L.P.C.), phenols (11–15 L.P.C.), copper compounds (50–55 L.P.C.) and oil products. The pollution is especially obvious from village Koda to the place of its flowing into Khrami [15].

The polluted water flow increase the total amount of water stream into the rivers, but worsen water quality and as the result exhaust water reservoirs. Much water resources are used for industrial use and these polluted waters contain such dangerous chemical toxicants as: sulfates, cyanides, manganese, phenols, nitrites, copper compounds, oil products, etc.

Liakhvi, Tana and Tedzami rivers are polluted approximately at the same level. Their chemical composition is calcium-hydrocarbon, mineralization changes within 198–988 mg/l. Oxygen rate is satisfactory. Organic substances composition changes within 2–15 mg/l. The maximum concentration of contaminants are: ammonium nitrogen – 1.42 mg/l, nitrite nitrogen – 0.172 mg/l, copper compounds – 0.012 mg/l (L.P.C –12), phenols – 0,014 mg/l (L.P.C.-14), oil products – 0.91 mg/l [16].

Alazani and Iori rivers are considered the major arteries of Dedoflistskaro's municipality. These rivers flow into the Mingechauri water reservoir on Azerbaijan's territory. On Georgia's territory only several creaks are connected with it that are dry for long period of the year. On the Dedoflistskaro's municipal territory Ole river and some small ravines are connected with Iori.

River Alazani springs from the southern slopes of the Caucasus on 825 m elevation. The annual average expenditure at the upper mountain ridgehydroguard house is 95.1 m^3/s. Iori's average annual expenditure at Dali mountain water reservoir is 15.7 m^3/s.

Water monitoring on Alazani's water collecting basin was organized only at one point – Alazani-KvemoKeda [16]. The latest data is available only of 1985–1989 and 2002. The monitoring shows the following changes: BOD5 concentrations within 0.81–3.90 mh/l (L.P.C. – 3 mg/l); NH_4 – within 0.47–1.21 mg/l; NO_3, NO_2, PO_4 concentrations didn't exceed L.P.C. Dissolved oxygen (DO) concentrations were also satisfactory, within – 4.48–9.48 mg/l (L.P.C. – 4–6 mg/l). Proceeding from it we can conclude that in 1985–1989 and 2002 significant changes in water quality wasn't observed, though ammonium concentrations often exceeded L.P.C.

It is supposed, that Alazaniand its tributaries has been contaminated with organic and biogenic substances through sewerage systems, as well as, from legal and illegal industrial and waste sites, arablefarming, drainpipes and mud-torrents.

The main contributor of pointed pollution of lower part of Alazani's basin are Dedoflistskaro's communal waters. It takes place in little ravine of the Arthivi gorge that enters Alazani. According to the Ministry of environment and natural resources protection in 2011 869ths polluted water have been discharged into Alazani. The town needs sewerage waters purification system. The serious negative influence on ground and surface water objects is due to polluted diffusion springs.

In the extremely south part of Alazani, on Azerbaijan's territory, the concentrations of phenols 5–7 times exceed L.P.C., metals-6–8 times and oil products 2–3 times. It can be due to mud-torrents influence from urban territories of Kakheti, as well as, small oil businesses [17].

The accidents of high water pollution with nitrite nitrogen and ammonium nitrogen was fixed in some rivers of Georgia. For example, in 2005 in Suramula river the maximum index of nitrite nitrogen reached 0.246 mg/l (L.P.C. – 13.3). Very high level of pollution was fixed in Vereriver, where nitrogen concentration was 0.2 mg/l (L.P.C. – 10) [16]. The active surface synthetic substances was noticed almost in all rivers of Georgia. The exceeded concentrations of iron was fixed in Lekhura, Mashavera, Mtkvari Faravani, Alazani and Suramula.

According to "Sakstat" (Statistical agency of Georgia) in 2005 and 2013 from natural water objects was taken: in 2005–48785.674 ml m^3 water among it, fromground water –548.888 ml m^3. During the year was used 48374.14 ml m^3, among it for drinking and economy – 358.031 ml m^3, for industry – 208.256 ml m^3, for watering – 86.742 ml m^3, for agriculture supply – 18.817 ml m^3 and for electro-generation – 47702.294 ml m^3. Altogether, insurface water objects was flowed – 47732.165 ml m^3 water, among it: – 517.481 ml m^3 polluted, 47205.8 ml m^3-normatively cleaned and 8.874 ml m^3-normatively purified [18].

In 2013 from natural water objects was taken 28632.1 ml m^3 water, 1.7 times less than in 2005. Among it: from ground water objects – 403.2 ml m^3, that is, 145.7 ml m^3 lesser. During the year was used 27436.8 ml m^3 water, that is, 95.8% from all amount, among it: for communal need-448.2 ml m^3, industry – 324.6 ml m^3 and the remained water was used for agriculture and other needs. In the surface water objects was flowed 27144,0 ml m^3 water, 438.2 ml m^3-unpurified.

Into Georgia's surface water objects was flowed the following pollutants: organic substences-6.9ths.t (from this amount into Mtkvari-3.6ths.t), oil products-200 t (in to Mtkvari-2t), suspended particles-18ths.t (into Mtkvari-8ths.t), ammonium nitrogen-96t (into Mtkvari-74t).

The polluted flowing waters are divided: water-supply and sewerage – 344.1 ml m^3/y (67%); heat-and-power engineering – 163.8 ml m^3/y (31%); and industry – 9.6 ml m^3/y (2%).

Hereinafter we present some examples of surface water pollution. By joint-stock company "Energy-invest" in 2006 flowing water expenditure was 1978.6ths.m^3/s. The flowing waters are connected with Tbilisi-Rustavi regional purifying station where they are mechanically purified. The major contaminant is ammonia and it's concentration exceeds L.P.C. The plant doesn't have water purifying system.

From joint-stock company "Rustavi Metallurgical Plant" flowing water expenditure in the same year was – 184.3ths.m^3/s. The flowing waters are connected with Rustavi sewerage system and then flow to Rustavi regional purifying object. After purification it flows into Mtkvari. Proceeding from this analysis we can say that it is necessary to have perfect purifying cycle (mechanical, chemical, biological).

Inefficiency of purifying systems and unpurified waters flowing into water objects arouse the necessity of dilution to the limited concentration. The frequency of dilution is decided separately each time. Sometimes there is necessity of

10–15 time dilution with clean water as to restore its natural quality.

Particular concern is small rivers that make the major part of hydrographical network of Georgia and are giving 75% of total water flow of the year. Unfortunately, less attention is paid to their use and condition. Taking water from small rivers is more sensible for their ecosystems than from the large ones. The small rivers that flow through big towns often are becoming the collectors of flowed waters from industrial objects. For example, Vere river that flows in Tbilisi besides pollution of feces waters of village Tskneti and Vake district of the town is also polluted from different industrial objects. The following contaminants are found in the river: ammonium compounds (8–27 L.P.C.), oil products (60 L.P.C.), sulfates (10 L.P.C.), phenols (30 L-P-C.), copper compounds (25 L.P.C.), bacteriological substances (intestinal bacillus, saprophytic bacteria) [19,20].

Ksani and Aragvi rivers are very significant for Tbilisi's provision with quality drinking water. Especially concerning is the present condition of alluvial sedimentary ground waters of Aragviterraces' flood-lands and the condition of water expenditure of Zhinvali's principal and Bodoni's buffer reservoirs. Pollution of feeding rivers is threatening the ground waters contamination with toxicants and worsening the drinking water quality. Hydro-monitoring research of Sagduramo and Tchopotri in filtration basins in borders of MukhraniValley showed that the amount of toxicants in water is above L.P.C.

In the process of economy development of the country pollution of surface and ground waters will increase. So, for minimization of adverse results the following measures are recommended: creation of effective system of control on expenditure and quality of flowing and ground waters; rational disposition of water capacity enterprises according to water resources; inculcation of circulating, repeating and consecutive water systems; modernization of all water purifying systems. The principal conception of water resources preservation from pollution must be banning of flowing unpurified waters into natural water objects.

Utilization and protection of water resources is the national problem and must be regulated and supervised by the government so, appropriate legislative base and regulations should be prepared to guarantee the reasonable use of water resources of the country according to the principles of sustainable development.

Conclusion

There are 26060 rivers in Georgia with average annual water flow of 65.8 km^3. From this amount 7951 rivers with 16.1 km^3 of average annual water flow belong to the Caspian Sea basin. Our research of ecological condition of the major rivers of east Georgia flowing into the Caspian Sea let us to make the following conclusions: – the main contaminants of researched rivers are: ammonium, nitrogen of nitrates and nitrites, heavy metals, pesticides, phenols, oil products, etc. The rivers and other water objects are polluted with discharges from industrial plants, communal services, agricultural activities, rubbish, etc.; – high level of pollution is observed in Mashavera and Kazretula rivers, because of polluted discharges from joint-stock company "Madneuli's" open-cast mines; – the polluted rivers are very dangerous for ground waters, soils, agricultural products, environment and peoples' health; – for preservation rivers and other water objects from pollution it is necessary: to ban polluted waters flow into rivers and water objects without purification; organize water purifying systems with full cleaning cycle; create water quality control system, with special control laboratories; constant water monitoring and quick reaction on any violations; informing public about ecological condition and purity of drinking water.

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